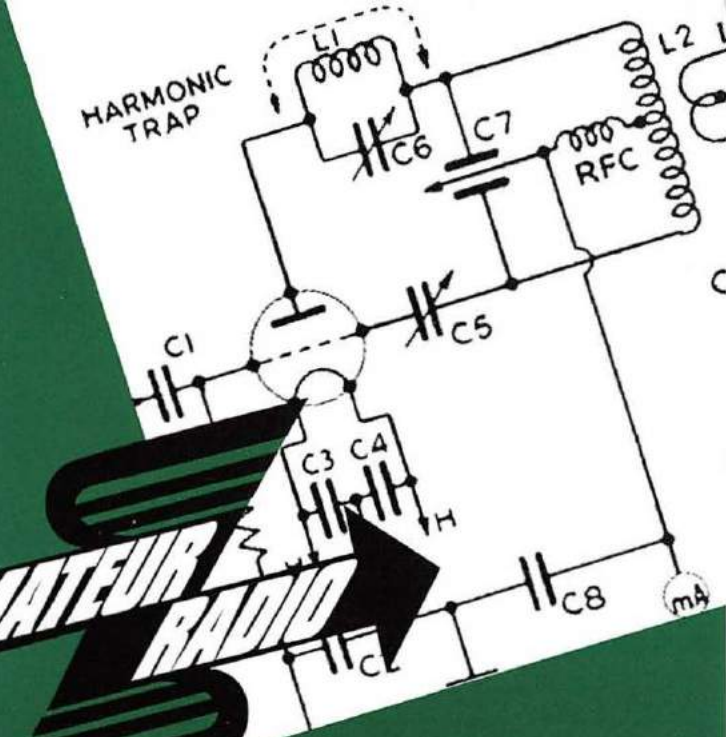


AMATEUR RADIO

TRANSMITTER INTERFERENCE

AN RSGB PUBLICATION

TRANSMITTER INTERFERENCE

Published by the

INCORPORATED RADIO SOCIETY OF GT. BRITAIN

New Ruskin House, Little Russell Street, London, WC1

November, 1948

CONTENTS

	Page
Chapter 1	
CO-OPERATION AND GOODWILL ..	3
Chapter 2	
INTERFERENCE TO MEDIUM-WAVE BROADCAST RECEPTION	4
Chapter 3	
INTERFERENCE CURABLE AT THE TRANSMITTER	6
Chapter 4	
INTERFERENCE CURABLE AT THE RECEIVER	8
Chapter 5	
INTERFERENCE TO TELEVISION ..	13
Appendix	29

Co-Authors : **J. W. MATHEWS (G6LL)**

A. O. MILNE (G2MI)

General Editor : JOHN CLARRICOATS (G6CL),
General Secretary, Incorporated Radio Society of Great Britain

CHAPTER 1 CO-OPERATION AND GOODWILL

WITH the very great increase in the number of radio amateurs now holding transmitting licences, it is inevitable that there should also be an increase in the number of cases of interference to broadcast and television programmes caused by transmissions from amateur stations. It should be realised, however, that the official attitude to the problem is that reception from the two main local broadcast stations, and the local television station, should be free from interference. The receiver must be of reasonably modern design, which excludes the single tuned-circuit valve receiver and the crystal set. Interference to foreign stations and to short-wave reception is regarded by the authorities as a risk which the broadcast listener must accept.

Co-operation Essential

Since it naturally follows that the amateur wishes to live without friction with his neighbours, a great deal of tact, patience and forbearance is necessary in dealing with complaints, especially as some broadcast listeners or television viewers are apt to assume they have a prior right to any reception. It is, therefore, highly desirable that the amateur's attitude should be co-operative and friendly. It is a first duty for him to show the listener that he is anxious to cure the trouble. He should make no attempt to conceal his whereabouts, in fact it is good policy, from time to time, to announce the station address and telephone number over the air with an invitation to anyone experiencing interference to make their difficulties known.

He should be prepared to give interested neighbours an opportunity to see his station in operation, an action that makes for mutual goodwill and one which will serve to dispel the commonly-held, but erroneous, belief that amateur stations work in the broadcast bands. The ability to receive broadcast or television signals free from interference in the amateur's own house should be demonstrated to a complainant. The truth of the old saying that "charity begins at home" is very real in such circumstances. The amateur who has ensured that his own family enjoys interference-free reception, will also have gone a long way towards making this possible for his neighbours. Apart from all other considerations, it is undesirable to bring Amateur Radio into disrepute with the general public.

When a direct complaint is made, prompt attention is most important. The spirit of co-operation will be encouraged if an immediate attempt is made to discover the nature of the trouble, even if a remedy cannot be applied at once. It must be emphasised, however, that, before any investigations are commenced, the amateur should be absolutely certain that his own apparatus is functioning correctly, and is not producing interference due to misadjustment, spurious oscillations, harmonics, over-modulation or key clicks. Only when everything possible has been done at the transmitting end should he consider fitting suppression devices to a receiver.

Even when it can be proved that the remedial measures must be applied at the receiving end—which usually is the case—it is good policy to offer to supply the necessary suppressors free of charge rather than haggle over any questions of responsibility.

The Broadcast Set and the Listener

It is unwise for an inexperienced person to interfere with the internal

wiring of a broadcast receiver or television set. If the amateur is not familiar with this kind of work, he should enlist the aid of an expert. His contacts in the local radio society or R.S.G.B. group should be helpful here.

It cannot be too strongly emphasised that the average listener is not equipped with technical knowledge. A simple, straightforward explanation avoiding technical terms, is essential in dealing with a complaint. The listener may not understand why it is necessary to fit some device to his receiver, and may be inclined to blame any subsequent fault in his receiver to this cause. This, in turn, may lead to the amateur being asked to effect repairs that have nothing to do with him. For this reason it is important to indicate to the dealer or serviceman who may be subsequently called in to deal with any normal fault, that the receiver has been treated for interference suppression. This will ensure that suppression devices are not removed as " non-standard " additions. It is a good plan to affix a notice inside the receiver stating what modifications have been made and for what reason. This notice should be signed and dated by the amateur concerned.

The Importance of Goodwill

It should be remembered that there are thousands of broadcast listeners to every transmitting amateur. Retention of goodwill is, therefore, of paramount importance. It should never be overlooked that local ill-feeling, which may have little personal effect on the amateur himself, can often make things very unpleasant for his wife or other members of his family.

In the following pages the various forms of interference are dealt with in detail together with the appropriate curative measures. Very few cases of interference are incurable given patience and goodwill.

Finally a word to the newcomer to Amateur Radio. Do not stay off the air because you think you will cause interference; this is a negative and unworthy attitude. From the very start make every effort to ensure that anyone in trouble comes to you immediately and does not wait until infuriated beyond bounds, when he will probably regard you as a menace. In really difficult cases, do not hesitate to call upon the good offices of the Interference Section of the G.P.O. Radio Branch, which exists to help both sides and is always ready with good advice and practical help.

CHAPTER 2 INTERFERENCE TO MEDIUM-WAVE BROADCAST RECEPTION

FOR convenience the main types of interference to receivers working on the normal broadcast frequencies may be classified into five groups. Remedies will, of course, vary considerably with local conditions and no general cure can be claimed as effective in all cases.

Causes of Interference

The five main types of interference are those caused by:

1. Key clicks, thumps and spurious emissions, such as parasitic oscillations, over-modulation and harmonics, all of which are curable only at the

transmitter. Most of these, incidentally, also come under the heading of "Transmissions on other than the authorised frequency band."

2. Blanketing, which may mean anything from a rather tiresome variation in the volume of the broadcast programme, to a bad case where the programme entirely disappears.

3. Cross-modulation which results in the appearance of an unwanted signal only at points on the tuning scale where strong broadcast programmes also appear; the interference not being audible over the remainder of the tuning range.

4. Break-through, which exhibits itself as the appearance of an unwanted signal over most, if not all, of the broadcast band. Although interference is severe it does not usually affect the volume of the broadcast programme.

5. Second channel and superheterodyne interference, which shows up as tuneable appearances of an unwanted signal at certain points on the broadcast band, not necessarily associated with any other station.

It will be appreciated that more than one type of interference may be present at any one time and, further, that these may reach the receiver by one or more routes, or a combination of several routes. In general, however, interference arrives at the receiver either by way of the aerial or through the mains connection. Sometimes it may be picked up by the actual set wiring but this is relatively unusual.

If interference is entering the receiver by way of the aerial or earth leads only, then it will cease as soon as these leads are removed from their sockets. Such interference may be excluded by the interposition of a suitable filter. (See Chapter 4.)

A Typical Case

In the meantime let us assume a typical case. A complaint is received—"Do you know you are blotting out our wireless?" It is often couched in more forceful terms, but the essentials are the same every time.

After checking the transmitter, a visit should be made without delay to the complainant's home and arrangements made for the transmitter to radiate during the visit. Ways and means of doing this satisfactorily are discussed in a later chapter.

Particularly where interference is not due to telephony and, therefore, not clearly identifiable, it should be borne in mind that it may not be due to the amateur station at all. If this is so, a clear and reasonable explanation should be given. If the interference is definitely identifiable and is due to the amateur station then it should be admitted at once. Any attempt at bluff or denial only makes things more difficult for everyone concerned, especially when the aggrieved listener calls in the Post Office. It is also worth remembering that the average listener will not appreciate derogatory remarks regarding either the age, selectivity or appearance of his receiver. You may think it is an antique relic. It is a mistake to say so!

Tracing the Cause of Interference

Having identified the interference, it should then be classified, if possible, into one of the five groups mentioned earlier, and the point of entry ascertained. First remove the aerial and then the earth leads and note the result. If the interference ceases the answer is obvious. If it does not, or even increases, it is probably arriving *via* the mains lead. An increase of volume being due to A.V.C. action caused by the removal of the aerial lead.

As mentioned previously, more than one type of interference may be present and more than one mode of entry involved, but the various forms

are easily distinguished from each other, and it is the predominant one which should be tackled first.

Tests such as those mentioned above are a matter of routine. Curing the trouble is a matter of careful, systematic and progressive elimination.

Mains borne interference may be due to feed-back through the mains wiring at the transmitter itself or, more often, to unscreened mains wiring in the vicinity, acting as an aerial, picking up energy radiated by the transmitting aerial. This is very prevalent in many modern housing estates where much of the house wiring is carried out with unscreened cab-tyre cable.

It is at this point that the difficulty of dealing adequately with all the possible combinations, in a publication of this type, becomes apparent. In Chapter 4 will be found a detailed selection of typical cases of interference and the measures taken to cure the trouble. Intelligent application of these cures should see most amateurs safely through their difficulties so far as broadcast interference is concerned.

CHAPTER 3 INTERFERENCE CURABLE AT THE TRANSMITTER

KEYING is the chief cause of interference from a telegraphy transmitter, but this trouble may usually be cured by one or more of the devices to be described. Interference from this source takes the form of clicks or thumps, sometimes accompanied by hum, in the neighbouring receiver.

Interference from telephony is not curable at the transmitter, unless it is due to misadjustment or over-modulation. In this connection it is desirable to point out that the modulation level should always be kept low during the main broadcasting hours in order to ensure that the peaks of speech do not over-modulate. Again emphasis is placed on the need for the amateur to ensure that his apparatus is correctly adjusted and that no over-modulation is taking place.

Key-Thump

Key-thump may be cured in a number of ways depending on the method of keying used. One of the most common places to insert the key is in the cathode circuit of one of the early stages of the transmitter, and occasionally in the oscillator circuit itself. This later method produces a more severe click at " break " than at " make " and is strangely difficult to eliminate completely. It may, however, be reduced considerably by employing the

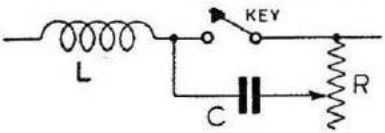


Fig. 1.
A thump filter for keying in D.C. leads. The inductance L is usually iron-cored.

arrangement shown in Fig. 1, which consists of an inductance L in series with the key, and a condenser C and resistance R in parallel with it. The inductance will reduce the clicks on " make " and the condenser-resistance

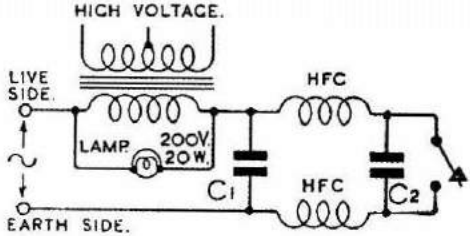
combination at " break." The inductance should be any value up to 50 Henrys with no current flowing, and the value of C varied between ·1 and ·5 μF. R can be between 25 and 500 ohms according to C. This thump-filter can also be used with success if anode circuit keying is employed.

Primary Keying

The practice of keying in the primary circuit of the H.T. transformer has been found to be very successful in eliminating clicks, but is apt to give " tails " to the Morse characters unless the smoothing condensers are kept to small values. A fairly heavy " bleeder " current will also help. Some load should be connected across the primary to stop heavy surges. A primary keying arrangement is shown in Fig. 2.

Fig. 2.
Primary keying.

C1	0·01 μF to 0·05 μF.
C2	0·001 μF.
HFC	210 turns No. 30 D.S.C. on 5" former.



Grid Blocking Keying

The method known as grid block keying is illustrated in Fig. 3. When the key is " up " a large negative bias is applied to the grid of the valve being keyed thus shutting off all anode current. In the " down " position this additional bias is shorted-out through a high resistance ; a value above 100,000 ohms will be satisfactory.

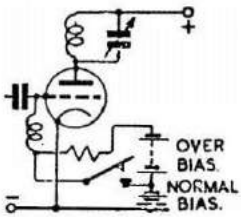


Fig. 3.
Circuit of Grid blocking keying.

Valve Keying

An excellent clickless keying circuit is shown in Fig. 4, where V2 is used as the keying valve. When the key is " down " this valve will pass the cathode current of V1 with only a few volts drop. Although the circuit shows directly-heated valves, it is equally suitable for use with indirectly-heated types. If a directly-heated valve is used for V2 then a separate filament supply is necessary. Several methods of valve keying are possible, but the arrangement described has been found to be free from click.

Use of Relays

It should be borne in mind that when using a relay for keying, a thump or click will take place on the make or break of the relay contacts, and that a further click will occur as the key itself completes the circuit through the energising coil of the relay. The filter shown in Fig. 1 should overcome this trouble, but it may be helpful also to include two R.F. chokes in series with the leads to the relay contacts, close to the relay. Fig. 5 shows this arrangement.

Trial and Error

Since no exact values can be given for any of the suppression devices described, owing to each case requiring individual treatment, a system of trial and error must be adopted and this often calls for considerable patience.

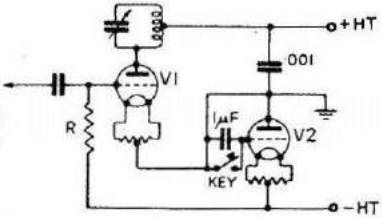


Fig. 4.
Valve keying circuit.
V1 may be either an oscillator or buffer stage.
V2 may be any low impedance triode capable of passing the current required by V1.

Interference from parasitic oscillation can take place but is usually not serious. Any of the normal forms of anti-parasitic device can be used, including R.F. chokes, shunted by a low resistance in the anode circuit,

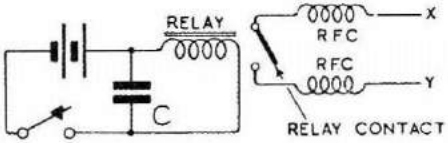


Fig. 5.
Interference suppressors in a relay keying circuit.

close to the anode of the valve. The chokes may conveniently take the form of a few turns of 18 S.W.G. wound round, but not touching, a 50 ohm resistor of suitable wattage. Care should always be taken when neutralised circuits are used to ensure that oscillation does not occur at any time.

CHAPTER 4 INTERFERENCE CURABLE AT THE RECEIVER

THIS Chapter deals in detail with the types of interference classified as Groups 2, 3 and 4 in Chapter 2. It is again emphasised that several types of interference may be present simultaneously. For this reason do not be discouraged if success is not achieved immediately.

Blanketing

Interference due to blanketing usually affects the volume of the received programme and is almost always due to the unwanted signal appearing at the grid of an early valve in the receiver, by way either of the aerial or earth lead.

It may be that either the selectivity of the receiver is poor, or that, although reasonably good for broadcast reception, it is not good enough to deal with a very high signal-input from a transmitter only a few yards away. Removal of the aerial or earth lead usually stops the interference or reduces it to a

very low level, and a permanent cure may be effected by the insertion of a series filter in the aerial lead.

The simplest cure in cases where interference is not severe, is to insert a small series condenser in the aerial lead close to the receiver. This has the effect of reducing the coupling of the aerial to the set, and provided the gain of the receiver is sufficient no appreciable difference in broadcast reception will be noticed. The capacity should be between 250 and 500 $\mu\mu$F, the best value being found by experiment.

In cases where a long outdoor aerial is in use, it is often advantageous to shorten it considerably. The insertion of a small series condenser will do this electrically if the owner does not wish the aerial to be cut.

In this connection, it is wise to give some thought to the transmitting aerial. It should be placed as far as possible from any broadcast receiving aerial, and if possible at right angles to it. Needless to say if feeders are used they should be carefully matched to avoid radiation.

For medium cases where wipe-out is not complete, an untuned series filter as shown in Fig. 6A, will usually clear the trouble. A convenient filter may be made by winding a piece of wire a $\frac{1}{4}$ wavelength long, on a former $\frac{1}{2}$" to $\frac{3}{4}$" in diameter, and connecting this in series with the aerial of the receiver as near to the aerial plug as possible.

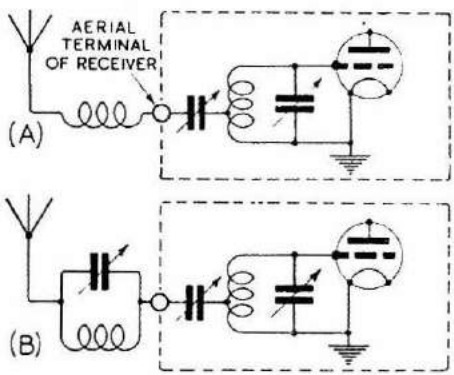


Fig. 6.
Showing how an untuned (A) or tuned (B) wave-trap should be connected between the aerial and the first tuned circuit of a broadcast receiver.

Should the listener wish to use the short-wave bands—very few ever do—or should the interference be really serious, a tuned filter of the type shown in Fig. 6B should be used, and arrangements made to switch it out of circuit when the short-wave range is in use. Such filters are most effective when the coil is large and the value of the condenser relatively small. Treatment of this type of interference is the same whatever the frequency of the transmitter.

For more serious cases still a low-pass filter may be inserted in the aerial lead, again close to the receiver. The circuit is shown in Fig. 7. This filter is more suitable for removing interference caused by 1·7 Mc/s. or 3·5 Mc/s. transmissions, than for the higher frequency bands.

It is essential that the coils be wound with No. 30 D.C.C. wire with the turns touching and secured in place with Durofix or similar cement so that they do not become loose. They may be wound on valve bases, or any other $1\frac{3}{8}$" diameter former. The condensers must be of a reliable make and of the mica type. Winding details for the coils and the capacities of condensers

required for various bands are given in Table I. It should be noted that the filter for the 1·7 Mc/s. band can be used on the 3·5 Mc/s. band, but that the 3·5 Mc/s. filter is not suitable for use on 1·7 Mc/s. transmissions.

TABLE I.

Coil	Turns 1·7 Mc/s.	Turns 3·5 Mc/s.	Turns 7·0 Mc/s.
L1	20	20	13
L2	30	30	20
L3	27	13	9
C	·0002 μF	·0002 μF	·0001 μF

The filter is arranged to have a characteristic impedance of 400 ohms at each end, as this figure is likely to suit most aerials and receiver input circuits. The loss at broadcast frequencies is negligible.

If the interference disappears only when the earth lead is disconnected, it is probably a case of coupling due to a common earth connection, *i.e.* both transmitter and receiver connected to the water pipe. Use of a separate earth for one or the other will effect a cure.

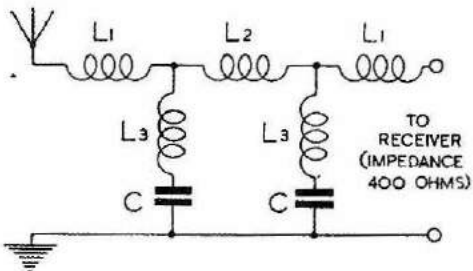


Fig. 7.
A low-pass filter which can be added to a broadcast receiver to eliminate interference.

Cross Modulation

The primary cause of this type of interference is similar to the previous form of "blanketing," but only occurs with a modulated transmitter. It can easily be recognised by the fact that the speech appears on top of all or most of the broadcast stations when tuned in, but does not appear between stations.

It is caused by a severe overload of the first R.F. valve of the receiver, which, due to this, commences to rectify signals from the local transmitter. When the receiver is tuned to a station the broadcast carrier is modulated by the rectified signal already present in the R.F. stage and as a result is passed to the detector stage together with the broadcast signal, and consequently both appear in the output. It will be seen, therefore, that the presence of both signals simultaneously indicates this form of interference.

The cure is to reduce the amplitude of the signal from the amateur transmitter in the first R.F. stage of the broadcast receiver, and any of the remedies

previously suggested may be used. In addition, since this trouble more often occurs in a receiver having an R.F. valve with non-variable-*mu* characteristics the substitution of a variable-*mu* valve in this stage may improve matters. A further cure can often be effected by the connection of an R.F. choke direct to the grid of the first R.F. stage in series with the lead thereto. It may be necessary to screen this lead.

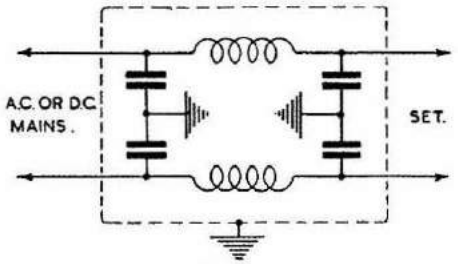


Fig. 8.

Interference suppressors in the mains leads to transmitter or receiver. The earthed metal box containing the filter is a precaution against direct pick-up or radiation by the chokes.

Break-Through

The audible effect of this type of interference is the same as for blanketing, but it is unusual for the interference to be so strong or for it to affect the strength of the signals received from the broadcast station. This is because the point of entry is usually by way of the mains lead and very occasionally by way of the wiring of the receiver itself. In the first place, therefore, a capacity of between ·0001 and ·001 μF should be connected from the "live" side of the mains socket to chassis. If this cures the trouble, it is unnecessary to go further, although an equally effective cure can usually be made by connecting the condenser from one side of the heater line to chassis. The condenser may then be an ordinary low-voltage paper type as it is connected across only a few volts A.C. If it is necessary to connect the condenser across the mains, it should be of good quality with mica insulation. In the case of a receiver suffering from 28 Mc/s. interference this lead to chassis must be as short as possible. Connection of the condenser by means of a lead several inches long may be useless, whereas a complete cure may often be effected by cutting this down to half an inch.

Many broadcast receivers have the various decoupling condensers and other "earthy" leads joined to an earth wire which may be anything up to a foot long connected to chassis at one end only. At frequencies above 28 Mc/s. in particular, an amateur soon realises that the opposite end of a piece of wire earthed at the other end is far from being at earth potential to R.F.! By the simple expedient of connecting such a lead to chassis at more than one point, serious interference can often be eliminated.

Should interference still persist from this source, a more elaborate filter should be fitted in the mains lead. A suitable circuit is shown in Fig. 8. Good quality condensers only should be used, and care taken with the insulation. The filter must be screened in a metal box which should be earthed, and connected as close as possible to the receiver, otherwise the lead between the filter and the receiver may require screening.

Cases have been known where interference of this type still persists even after a mains filter has been fitted.

This points to pick-up by the set wiring, and may occur at the most unlikely places. On A.C. or battery sets the offending stage may be found by the simple process of removing the valves in turn beginning at the R.F. amplifier (if any), to the power valve, noting when the trouble ceases. Rectification can take place even on the grid of the output valve, a 5,000 ohms carbon resistor in series with the grid and a ·0001 μF condenser from grid to cathode usually effects a cure. Incidentally this is an excellent cure for R.F. in modulators and audio amplifiers of all types, except Class " B " output stages.

In one receiver R.F. was being fed into the circuit due to a rather long gramophone pick-up lead. A ·0001 μF condenser connected to chassis overcame the trouble. The insertion of an R.F. choke in the grid lead to the detector stage, close to the valve, may also assist to cure this form of interference.

Second Channel and Super-Heterodyne Interference

It is perhaps not correct to include this trouble under the heading of interference curable only at the receiver. It is, however, a receiver fault, and not due to radiation by the amateur station on an unauthorised frequency.

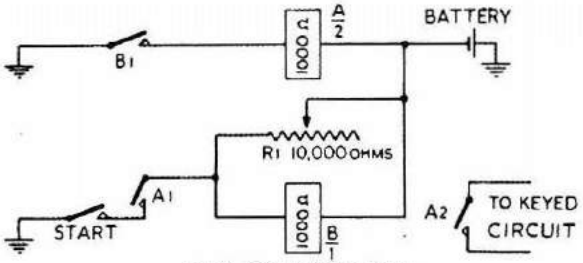


Fig. 9. Circuit of Auto-Keyer.

Due to the choice of intermediate frequency in the receiver it is possible for the amateur station to produce a signal at the I.F. of the receiver by beating with the oscillator frequency or alternatively by some other combination of strong signal or harmonic either of the amateur signal or super-het. oscillator. It may be necessary to screen leads in the receiver or to take other steps to prevent the signal from the transmitter combining with the local oscillator of the receiver.

Probably the easiest course is to find, and then avoid, the spot frequencies on the appropriate amateur band which cause the trouble.

Remedial measures are often a matter of progressive reduction. Attention to the points already mentioned will usually be all that is necessary, but in a difficult case, anything which reduces interference and does not materially affect the broadcast reception should be incorporated until interference disappears. Success has, before now, attended the completely unscientific course of tapping around with a chassis-connected ·0001 μF condenser to find points in the wiring of a receiver where interference can be reduced.

In general, however, there is nothing in the problem of broadcast interference once it is faced and tackled fearlessly. No two types of broadcast receiver are alike and some seem to be designed in order to render servicing

as difficult as possible; some even hardly appear to be " designed " at all ! Good clean layout, accessibility and short earth returns are most important. If all manufacturers would by-pass the heater line on their receivers in the manner suggested, much of the trouble with broadcast interference from amateur transmissions would never arise.

Automatic Key to Send Dashes

Should it be necessary to arrange for the transmitter to be keyed during broadcast interference investigation, the simple unit shown in Fig. 9 will prove very useful. The device will cause the transmitter to send dashes of varying length, according to the prearranged position of R1 which acts as a release delay slug on relay B.

The operation is as follows : When the " start " switch is closed, relay B is energised and contact B1 energises relay A. A2 operates the keying circuit and A1 opens, de-energising relay B. Relay B, however, releases slowly due to the slugging effect of R1. When B releases, B1 releases relay A. Contact A1 restores, re-energises relay B and so the cycle continues.

Telephony may be simulated by receiver feed-back to the microphone or by passing the output of an audio oscillator through the modulator. The transmission of modulated or unmodulated signals may be controlled by pre-arrangement with someone left in charge at the transmitting end so as to reduce transmission to an absolute minimum. The station call-sign should be announced at the end of each test transmission and the reason for the test made clear. This announcement should, of course, be made by the licencee. If the complainant and the amateur are both on the telephone, tests can be made more easily and transmissions kept to a minimum.

Relays suitable for the test keyer are available from ex-Government surplus and will work quite satisfactorily from a 9 volt grid-bias battery for several hours.

CHAPTER 5 INTERFERENCE TO TELEVISION

INTERFERENCE to television reception is without doubt the most important problem at present facing the radio amateur and the radio industry. Due to its special nature, the problem requires special treatment, although most of the general remarks which concern broadcast sound interference apply, especially those which emphasise the need for co-operation and immediate attention to a complaint.

Owing to the rapid growth and extending hours of television, more and more radio amateurs are becoming aware that they will have to take steps to deal with the trouble if they are to retain the freedom of operating times they at present possess.

Interference generally takes the form of distortion of the picture, or a series of diagonal lines across it. Sometimes it is a trellis pattern, but in severe cases a complete blanketing occurs leaving the screen completely white.

Typical examples of pictures with interference such as could be caused by an amateur transmitter are illustrated in Figs. 10 and 11. From these it will be seen that even a small interfering signal can cause a very noticeable deterioration in the picture, and it can be assumed that any interference

above about – 40 db compared with signal level, is likely to cause trouble, and steps should be taken to reduce or remove it.

Harmonic Radiation

Generally, more interference troubles occur on the outskirts of the service area, due to the lower field strength of the vision signal. The most probable source of interference is, of course, harmonic radiation, from either the P.A. or driver stages of a neighbouring amateur transmitter, since certain of the amateur bands show harmonics in the Television range of frequencies. Table II, which illustrates this point, also indicates the bands where trouble may occur even when it would seem that no radiation in the Television band is taking place.

Fig. 10A.

In the case of transmissions in the 28 and 58 Mc/s. amateur bands it is possible that interference may be caused by harmonics from a 14 Mc/s. stage in earlier sections of the transmitter. This applies particularly to the 58 Mc/s. band since such harmonics would be nearer the 45 Mc/s. Television band than if the transmitter were working on a fundamental frequency in the 14 Mc/s. band. These harmonics can pass through the P.A. stage without serious loss, and can be radiated from the aerial.

Fortunately the radiation of harmonics is fairly easily controllable at the transmitter. With this in mind, amateurs should take steps to ensure that harmonic suppression devices are incorporated into any new apparatus they may build. Details of suppression methods are given later.

Television Receiver Design

The second, and more serious, cause of interference is due to certain features in television receiver design; such troubles cannot be cured at the transmitter end. The effect of this form of interference is that, although the amateur is transmitting on his licenced frequency, and is not radiating harmonics in the Television band, his signals appear in the sound or vision channels, or both, of the nearby receiver.

Some receivers have a local oscillator operating on 37 Mc/s. and an I.F. amplifier centred on

Fig. 10B.

Two television pictures showing the effect of C.W. interference at a level of (A) 0 db and (B) –10 db compared with signal level. The general effect being the black diagonal lines across the picture.

8 Mc/s. The second channel image frequency is, therefore, 29 Mc/s.—the centre of the 28–30 Mc/s. amateur band. The selectivity of the R.F. circuits at this frequency is totally inadequate to deal with the high field-strength of a local amateur transmitter.

The most satisfactory solution in this case is the insertion of a high-pass filter in the receiver aerial lead so as to attenuate severely signals between 28–30 Mc/s., while offering no deterrent to signals in the Television band. Suitable designs for such filters are given later.

Again, some receivers have I.F. amplifiers covering the 7·0–7·3 Mc/s. amateur band, and it requires only a very small amount of unscreened wiring between the mixer anode and the first I.F. grid to pick-up R.F. from a nearby amateur station working in that band. Certain makes have I.F.'s in the 14 Mc/s. band, and similar trouble can be caused by stations working in that band. Signals on these frequencies can be picked up by the aerial and passed through the mixer stage, reaching the I.F. stages in that manner. It is possible also that the feeder may accidentally be of such a length as to resonate with the 7 Mc/s. or 14 Mc/s. signals.

Fig. 11A.

Where interference is due to such causes, it would seem that, in the event of filters not proving satisfactory, screening the leads mentioned above is necessary, but this cure should not be attempted by anyone not really familiar with Television receivers. A mains filter and a high-pass filter in the aerial will also assist in overcoming this type of trouble.

Harmonics from Communication-Type Receivers

One further source of interference that occasionally occurs is due to harmonics from the oscillator stage of an amateur's own communication receiver. Such harmonics are sometimes sufficient to cause considerable trouble. Mains filters and further screening of the offending section of the receiver are likely to provide a cure.

Television Aerials

One point that should not be overlooked when investigating cases of interference is the efficiency of the Television aerial. In areas fairly close to the vision transmitter it is not unusual to find that the owner

Fig. 11B.

Illustrating two examples of interference having reached the synchronising circuits; (A) with a level of −20 db, and (B) with a level of −30 db compared with signal level.

of a perfectly good vision receiver is using for an aerial an odd piece of wire, or at best a quarter wavelength of wire, fitted up indoors. Such an arrangement is much more prone to interference than a properly designed outdoor aerial with a correctly matched feeder system. The latter arrangement should always be recommended in cases of interference. If it is argued that such an aerial gives too great a signal, the remedy is to introduce a simple attenuator between feeder and receiver. Devices of this nature are frequently supplied by a firm when erecting an aerial. Details of attenuating pads having various degrees of attenuation are given in Fig. 12. The correct amount of attenuation should be found by trial and error.

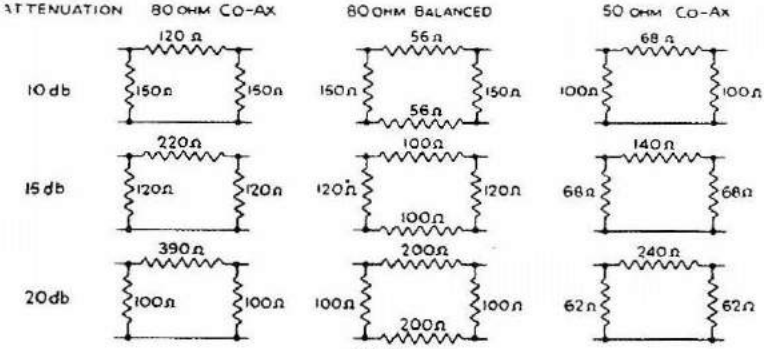


Fig. 12.

Details of attenuators for use in vision receiving aerials. For use see text. 80 ohm co-axial or balanced types are usually suitable for 70–80 ohm cables used on a single dipole. 50 ohm types are for use with the 50 ohm cable used with the dipole and reflector type of aerial. All values are taken as nearest 5 per cent. values on standard logarithmic numbers.

A good Television aerial without an attenuator may work too well and actually introduce interference, at the same time overloading the receiver with the Television signal.

Band. Mc/s.	Harmonic.	Range. Mc/s.	Chance of Interference.
1·715–2·0	21st, 22nd, 23rd, 24th	36–48	Negligible
3·5– 3·8	12th, 13th	42–49·4	Slight
7·0– 7·3	6th	42–43·8	Moderate
14·0–14·4	3rd	42–43·2	Serious
21·0–21·4	2nd	42–42·8	Serious
28·0–30·0	2nd	56–60	Serious
58·5–60·0	—	Funda-mental	Serious

TABLE II.

Shows the position for the frequencies used by the London Television Station.

Attenuators

Attenuators should be constructed in a metal box and suitably earthed, although this will be automatic if concentric sockets are used for the input and output connections to the aerial feeder and set input. In some cases it may be found that the fitting of an attenuator will cure interference troubles, since naturally the interference will be attenuated as well as the signal.

Suppression Devices

Before dealing in detail with the practice of curing interference it is desirable to consider the various points that are likely to require attention in a Transmitter and Television receiver. Fig. 13 shows a schematic arrangement of a transmitter, and indicates these points, while Fig. 14 shows the receiver.

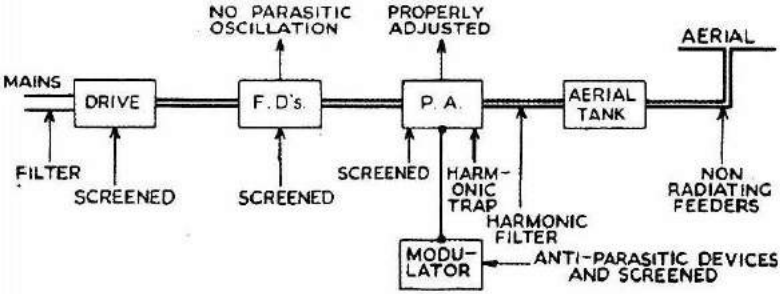


Fig. 13.
Schematic diagram of Transmitter showing points requiring attention to prevent radiation of harmonics.

Commencing with the transmitter, as the source of interference, a mains filter should always be installed. Due attention should then be paid to the screening in all its stages, followed by the incorporation of a harmonic rejector in any of the anode circuits which may require it. If the screening is properly carried out this should be necessary only in the P.A. stage. The permanent installation of a harmonic indicator in this part of the circuit is recommended, and details of such a device are given on page 22. In this

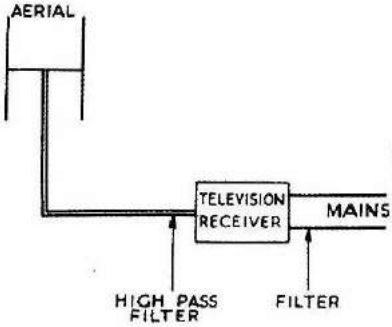


Fig. 14.
Schematic diagram of Television receiver showing points requiring attention to prevent pick-up of unwanted signals.

manner it will always be possible to keep a check on the harmonic radiation, and adjustments made as necessary when the frequency is changed. Finally, consideration should be given to the use of a link-coupled aerial circuit with a filter incorporated in the link line.

It is not always necessary to employ both a harmonic rejector and a filter in the aerial circuit, but in cases of severe interference and a low field strength from the vision transmitter it may be found desirable.

In certain instances the modulator, if of the Class B type, may require anti-parasitic devices.

At the receiving end a high-pass filter can be installed in the feeder line from the television aerial—provided it is correctly designed—and mounted close up to the receiver, whilst a mains filter should remove stray and slight interference that may be entering the receiver that way. In addition, the direct pick-up type of interference mentioned previously may necessitate modifications to the receiver. Attenuator pads as described may also be fitted.

Drive Frequency

Where transmission is required in the 28 Mc/s. or 58 Mc/s. band it is advisable to arrange that the frequency of the driving system, whether V.F.O. or crystal, shall be in the region of 5 Mc/s. or 10 Mc/s., so that the required frequency in the P.A. can be obtained by the use of a tripling stage for 10 to 30 Mc/s., thus avoiding the generation of any frequencies near the 45 Mc/s. band. This has proved completely efficacious in some cases.

The popular tri-tet oscillator is a prolific generator of harmonics and is extremely difficult to suppress, because much radiation can occur from the cathode coil. For this reason its use is not recommended where Television interference is likely to occur.

Suppression of Harmonics

It cannot be too strongly emphasised that it is of little use attempting to suppress the radiation of harmonics from a transmitter if it is poorly built, *i.e.* without proper earthing and screening, or is improperly adjusted. Parasitic oscillation, inaccurate neutralisation, as well as over-modulation, are all symptoms of bad adjustment. As the subject of transmitter construction and adjustment is dealt with in other Society publications, it is not proposed to consider it here.

If interference troubles are being experienced it may be well worth while to reconstruct the transmitter or at any rate the P.A. section of it, bearing in mind the points mentioned, especially the screening.

It should be remembered that the harmonics from a V.F.O. or crystal oscillator are often sufficiently strong in themselves to cause interference, and although the stage itself may be screened it must be recognised that the power supply leads to it require filtering and possibly screening. This applies especially when the unit is supplied from a power pack remotely situated, as is often the case with a V.F.O. where it is customary to have it close to the receiver and connected to the transmitter or to its own power pack by long leads. The leads from the power pack could quite easily be of such a length as to resonate with harmonics falling in the Television band, thus acting as an aerial.

A loosely coupled aerial circuit should always be used, preferably the type using a form of link coupling to the aerial tank circuit, which should be separate. A short length of concentric line is very convenient for this purpose, since it permits the easy installation of a filter, as described on page 19.

Fig. 15 illustrates an arrangement of the P.A. tuned circuit and a link-coupled aerial circuit. The advantage of this method is that any type of aerial can be coupled to the aerial coil, without any further adjustment or alteration being made to the harmonic filter, since it remains in an unaltered part of the aerial coupling system.

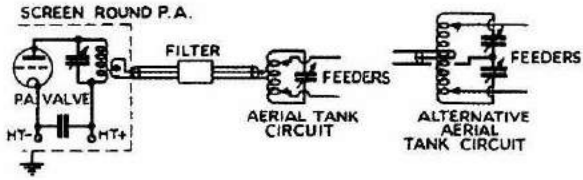


Fig. 15.
Shows a typical link coupled aerial circuit and how a filter can be installed. The link line may be any length within reason.

In the case of an aerial using low impedance twin (80 ohm) feeders, the separate tank may be dispensed with and the filter installed directly in the feeder line. Generally, however, it is a definite advantage to use the loose coupled system. Fig. 16A shows the arrangement of a filter suitable for a low impedance balanced line. Fig. 16B shows a re-arrangement with both networks in the same line.

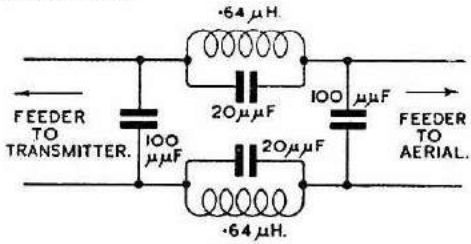


Fig. 16A.
Filter for use in 80–100 ohm balanced line between P.A. tank and aerial circuit or in low impedance feeder. Coils are 10 turns 16 S.W.G. on ⅜" former spaced to 1" winding length. Cut-off frequency about 18 Mc/s.

It should be pointed out that the harmonic suppression filters described have no effect at the fundamental frequency of the transmitter, having negligible loss at such a frequency. They will, however, attenuate very severely frequencies falling within the television range.

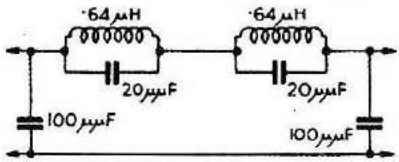


Fig. 16B.
Filter shown in Fig. 16A rearranged for use in 80–100 ohm concentric line. The centre conductor of the cable should be connected to the part of the filter having the inductances in circuit.

When used in feeders having an impedance of 300 or 600 ohms, slightly different values are required and these are given in Figs. 17 and 18. In Fig. 18B the same filter is slightly rearranged for use in a single wire feeder, such as a Windom.

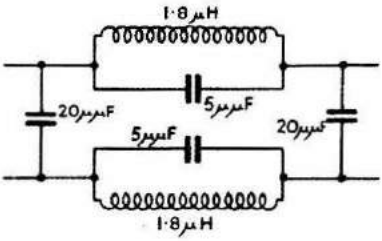


Fig. 17.
Rearrangement of filter shown in Fig. 16A for use in 300 ohm balanced line. Coils are 10 turns 18 S.W.G. on 1" dia. former spaced to 1" winding length.

The cut-off frequency of these circuits is about 18 Mc/s., although its exact value is immaterial. In each case an arbitrary cut-off has been chosen in order to quote condenser values which are conveniently obtainable.

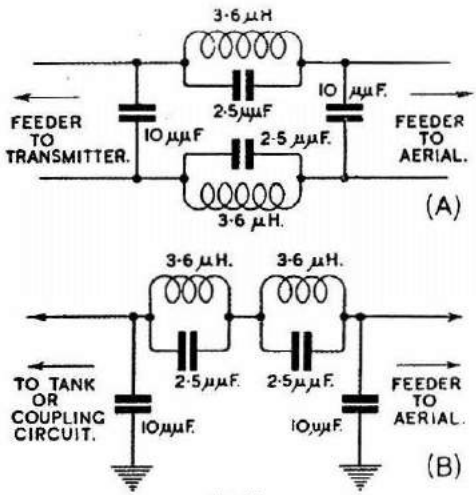


Fig. 18.
(A) Shows filter for use in 600 ohm balanced feeder.
(B) Re-arrangement of components for use in 600 ohms single wire feeder.
Coils are 19 turns 18 S.W.G. on 1" dia. former spaced to 2" winding length.

In these filters it is necessary to connect the condenser across the actual ends of the coil. Do not leave any length of lead on the coil. Also in the filter for the 80 ohm feeder keep the device as compact as possible, preferably soldering the condenser tags directly together without using any connecting wire. The feeder line need then be opened only an inch or so and connected

directly across the 100 μμF condenser. For the 600 ohm circuit it will be necessary to place the coils at a distance apart corresponding to the spacing of the line. The leads to the 10 μμF condenser should be straight, short lengths of stout wire or tape.

In cases where a matching network (Collins coupler) is used, the circuit can be modified to form an arrangement similar to the filters already described. This is done by connecting a small variable condenser across the series coils to tune them to the harmonic frequency, and will entail slightly resetting the other two condensers. Fig. 19 gives details of a suitable matching network.

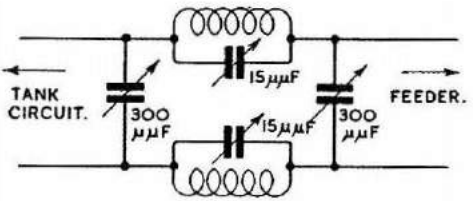


Fig. 19.
Suitable components for a matching network. Each coil to be made 5 turns on 2" diameter spaced to 1" winding length.

Where the optimum transmitter load and the feeder impedances are known, the circuit values can be calculated, but where an existing coupler is already working it should not be difficult to find the correct adjustments by trial and error.

It is advisable to use coils with no short-circuited turns. Such coils should be somewhat smaller in value than are normally required for 14 Mc/s. or difficulty may be met in tuning them up to 42 Mc/s., in fact the self-capacity alone may be sufficient, in which case resonance can be obtained at the correct frequency by varying the turns.

Using a normal type of coil with about five turns wound on a 2" former, a condenser with a maximum value of 15 μμF should be suitable.

To adjust the circuit a harmonic indicator, as described on page 22, should be loosely coupled to the aerial side of the network by means of a very small capacity, say about 5 μμF. The condensers across the coupler coils should then be adjusted until minimum harmonic is observed. Both condensers should be kept at about the same setting until the tuning position is obtained, when individual fine adjustment can be made. The main condensers will now require readjustment to load the transmitter correctly, but this should not be appreciable if the circuit is functioning correctly.

If an unbalanced network is used, the adjustment will be simpler, as there is only one small condenser to adjust. A maximum capacity of 10 μμF will probably be sufficient in this case as the coil will be about double the size used in the balanced variety.

If the separate tuned aerial tank circuit recommended above is used, it will be quite satisfactory to install one of these filters in the 80 ohm line coupling the P.A. to the tank circuit. In addition to the compact construction feature previously mentioned, the filter should not be coupled to the P.A. tank coil when fitted. The P.A. stage itself should, of course, be screened.

Harmonic Trap

Another very effective method of reducing harmonics is the use of a

harmonic trap in the anode circuit of the stage producing them. Normally the P.A. stage is the only one requiring this treatment. Fig. 20 shows how such a device should be fitted and gives the sizes of the coil and condenser needed. In the case of a push-pull P.A. stage, two traps will be required, one in each anode circuit.

The actual construction of the trap presents no difficulty. The condenser is mounted on a piece of Polystyrene about $2\frac{1}{4}'' \times 1\frac{1}{4}'' \times \frac{1}{8}''$ and supported on the anode tank condenser to allow very short connecting leads. The coil is soldered directly on to the trap condenser, with its axis at right angles to that of the tank coil. Any good quality midget air dielectric trimmer of capacity 3–20 μμF can be used. When calculating the size of the trap coil allowance must be made for the anode-to-filament capacity of the P.A. valve, and for stray capacities which may be effectively in parallel with the trap tuning capacity. The values given in Fig. 20 are for a valve having an anode-to-filament capacity of 0·4 μμF—such as a 100TH. The range of condenser values suggested will probably be suitable for most common types of transmitting valve.

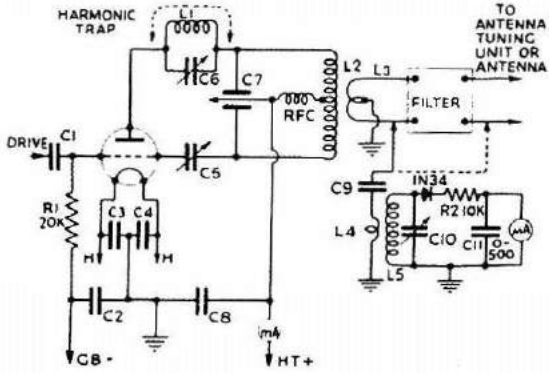


Fig. 20.
Typical P.A. circuit showing harmonic trap L1, C6, and harmonic indicator, together with aerial filter.

C1	50 μμF.
C2, 3, 4	Tubular paper. ·01 μF.
C5	Neutralising.
C6	3–20 μμF midget air-trimmer double-spaced.
C7	50–50 μμF transmitting variable.
C8	·001 μF H.V. mica.
C9	2–5 μμF.
C10	7–100 μμF midget air-trimmer.
C11	·001 μF.
L1	12 turns 18 S.W.G. bare copper wire $\frac{1}{2}''$ I.D. spacing $\frac{1}{16}''$.
L2	Normal tank coil.
L3	Link coil.
L4	One turn link adjustable.
L5	4 turns 14 S.W.G. enamelled copper $1\frac{1}{4}''$ I.D. $\frac{1}{16}''$ spacing.
R1	20,000 ohms 10 watt.
R2	10,000 ohms $\frac{1}{2}$ watt.

Harmonic Indicator

It is essential for the proper adjustment of the trap that some form of indicator be used which is capable of being tuned to the harmonic it is desired to eliminate. A simple device on the lines of that indicated in Fig. 21, should be made up. As shown, this consists merely of a tuned circuit, which is loosely coupled *via* a small capacity to the transmitter, a crystal detector

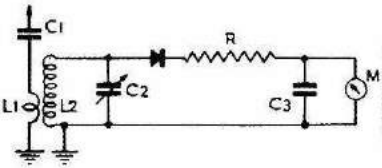


Fig. 21.
Circuit of Harmonic Indicator.
L1 1-turn link. L2 4 turns 14 S.W.G. $1\frac{1}{8}$" diameter, spacing $\frac{3}{16}$". C1 2–5 $\mu\mu$F Ceramic. C2 *Eddystone* type No. 583, with both sections in parallel. C3 ·002 or ·001 μF. R 10,000 ohms. M 0–500 microammeter, *Sangamo Weston*. Crystal detector *B.T.H.* type CG1C or *Silicon* type CS7A.

of the miniature micro wave type and a micro ammeter. Further minor refinements, such as connecting sockets and a phone jack, can be added if desired. The instrument described is illustrated in Fig. 22. The phone jack is included so that the indicator may be used as a monitor in the event of modulation of the transmitter causing spurious emissions on television frequencies. This is more likely to happen under conditions of over-modulation.

The indicator should be coupled to the output from the P.A. stage just tightly enough to give a full scale deflection on the meter when the circuit is tuned to resonance with the harmonic which is to be eliminated. It should be remembered that if a Silicon crystal is used it has very definite current limitations, and the meter needle should not be allowed to go "hard over" against the stop. A Germanium crystal on the other hand will pass more than sufficient current to burn out the meter. Equal care should therefore be taken if a crystal of this type is used.

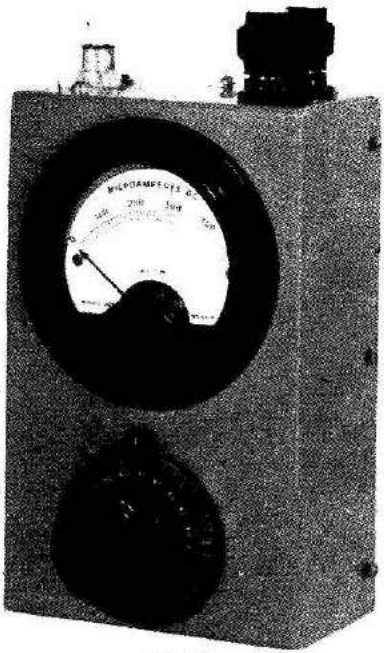


Fig. 22.
Harmonic Indicator. The miniature dial is an *Eddystone* type No. 595. The unit is contained in a metal box measuring 6" × $3\frac{3}{4}$ × 2" obtainable from *Amateur Radio Service* (G6HP). A *Belling Lee* concentric socket and *Belling Lee* insulated terminals are provided for alternative connection to the transmitter.

The method of using the device is as follows. The transmitter is first tuned-up in the normal manner with the P.A. anode harmonic trap circuit (or circuits if push-pull is used), short-circuited temporarily by a short lead fitted with crocodile clips. The harmonic indicator is then coupled to one side of the feeder line (or output link coil) through a small capacity of about 2 to 5 $\mu\mu$F as shown in Fig. 20. The indicator is then tuned to resonance with the P.A. harmonic which falls in the television band. This will produce maximum deflection on the meter. The coupling to the indicator should now be adjusted so as to produce full-scale deflection of the meter under this

reference condition. The harmonic trap shorting-link is now removed and the harmonic trap tuning control rotated by means of an extension spindle, until the indicator meter shows a minimum point.

In the case of a low power transmitter it may be necessary to connect the harmonic indicator link coil across the feeder through a small capacity in each leg—say 5 to 20 $\mu\mu$F—in order to obtain sufficient deflection of the microammeter. With large changes of frequency it will be necessary to readjust the trap tuning slightly, and in view of this it is strongly recommended that this control be brought out to the front panel for easy accessibility. In the same way a built-in harmonic indicator would be a great advantage, and its inclusion in the design of a 14 Mc/s. P.A. is greatly to be desired.

The indicator being very loosely coupled to the feeder produces negligible loading or unbalance. It may thus be left in circuit, when it will function as a permanent monitor of the transmitter harmonic output.

Should a feeder harmonic filter be used in addition to the anode trap circuit, its efficacy may be judged by shorting-out the trap circuit and observing the indicator deflection before the filter (*i.e.* full scale) and then clipping the indicator coupling condenser on to the feeder immediately after the filter and reading the indication thus produced. If necessary, the filter elements may be adjusted by this method for maximum rejection in the television band.

The 21 Mc/s. Band

When the 21 Mc/s. band is used trouble may be expected from 2nd harmonic radiation, as indicated in the table on page 16. The easiest method of reducing this source of interference either completely or to negligible proportions is to use a push-pull P.A. stage, since in a properly balanced circuit of this type the even harmonics cancel out. Care should, however, be taken to ensure that the stages are properly balanced, and since the two valves are unlikely to be exactly matched, the theoretically correct method of equalising the drive to each grid will not hold good in practice. The harmonic indicator should be coupled to the feeders *via* a very small capacity and the drive to each valve adjusted until the harmonic disappears. A similar result can be obtained by adjusting the bias on each valve individually, for example by using separate grid leaks or cathode resistors, and adjusting each until the 2nd harmonic is at a minimum.

Alternatively, if a single-ended P.A. stage is used, an anode trap similar to the one recommended and described for use with the 14 Mc/s. P.A. should be employed. The harmonic indicator will, of course, prove invaluable again in this case.

Modulators

Occasionally interference can be caused by Class B Modulators which emit spurious oscillations at R.F. on peaks of modulation only, and which modulate or radiate directly. The cure for this is to improve the modulator stability by using anode and/or grid stoppers, or any of the usual methods described either in the *Amateur Radio Handbook* or elsewhere.

Mains Filters

The design of a suitable mains filter is illustrated in Fig. 23. Such a device should be constructed in a metal box with a screen between the coils, and mounted in the main supply lead to the transmitter. A somewhat lighter construction can be used when it is intended to install the filter in the mains lead to the television receiver. Particular attention should be paid to the

insulation of the components. For this reason good quality condensers are essential. When a mains filter is fitted to a receiver the lead from the filter to the set should be short and screened.

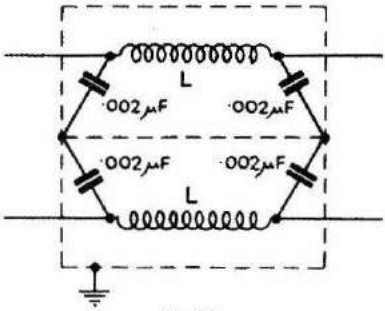


Fig. 23.
Circuit of mains filter to reduce 43 Mc/s. R.F. radiation. Dotted line shows screening box. The condensers should be mica 1,000v. test and of good quality. L = 69" of wire wound on 1" dia. former. For transmitter supply use 12 S.W.G., and for receiver supply 16 S.W.G.

High-Pass Filters

As stated previously, where interference is caused even when the amateur transmitter is radiating only in the licensed frequency bands, and where as much harmonic radiation as possible has been suppressed, a filter in the receiver aerial lead is usually the solution. Such a filter must pass television

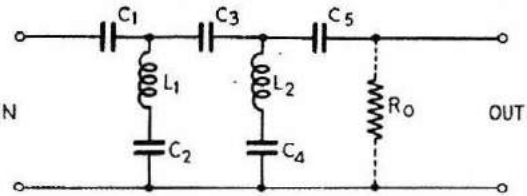


Fig. 24.
Simple two section filter with cut-off frequency about 30 Mc/s. and maximum attenuation at 14·3 Mc/s.

L1, L2 7 turns 16 S.W.G. on ¾" dia. former spaced to ¾" winding length. Length of coil leads not to exceed ¾" at each end.
C1, C5 71 μμF T.C.C., type CM23N. C3 35 μμF T.C.C., type CM23N.
C2, C4 520 μμF (470 and 47 μμF, type CM24N and CM23N, in parallel).
RO 80 ohms ½ watt. (when required).

frequencies without loss, and severely attenuate all signals on lower frequencies.

The circuit and details of a simple M-derived high-pass filter are shown in Fig. 24. This design attenuates frequencies of the order of 30 Mc/s. and below, but has maximum loss at 14·3 Mc/s. filter of this type should be constructed in a metal box with a screen betw n the two coils. The earthing of the screening box will be automatic i ncentric sockets are used for the input and output connections. The 80 o terminating resistance (R), need only be used where the input impeda f the receiver is

greatly in excess of this figure. The device should be included in the 80 ohms television receiver line as close to the receiver as possible.

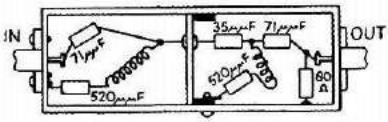
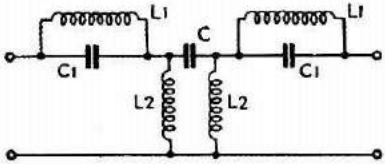


Fig. 25.
Layout of components of a simple 14 Mc/s. filter. The screening box measures 1½" deep, 2½" wide, and 5" long.

A further design of high-pass filter is shown in Fig. 26, but in this case maximum attenuation occurs at 29 Mc/s. Such a filter is intended mainly for use when interference is caused from a transmitter operated in the 28–30 Mc/s. band. It should be included as before in the receiver aerial feeder

Fig. 26.
Circuit of high-pass filter with maximum attenuation at 29 Mc/s. C = 25 μμF. C1 = 100 μμF. L1 and L2 = ·285 μH = 4½ turns 18 S.W.G., wound 16 T.P.I. on ½" dia. former.



close to the set. Constructional details are given in Fig. 27. A filter of this type will cure trouble caused by 28 Mc/s. signals reaching the receiver through the aerial lead, but it will not help when the interference is mains-borne or picked up directly by the set wiring. As can be seen by a study of Fig. 28, the filter will attenuate signals on all frequencies lower than 29 Mc/s., in fact it will probably be found effective on 14 Mc/s. transmissions except where the interference is severe. In the latter event the filter shown in Fig. 24 should be used in addition.

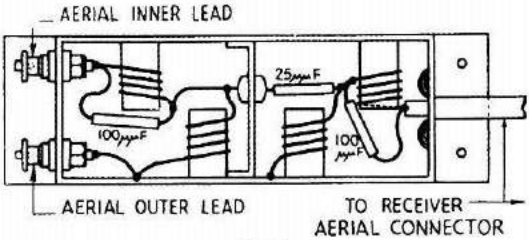


Fig. 27.
Layout of components of a 29 Mc/s. filter, in screening box. The braiding of the co-axial cable is unravelled and soldered to the inside of the box, unless concentric sockets are used. Terminals must be insulated from box, which measures 1½" deep, 2½" wide, and 5" long.

Single Side-Band Reception

A further method that has proved satisfactory in some cases, is to modify the receiver for single side-band reception using the upper side-band. This has the effect of reducing the band-width of the overall response thereby reducing the noise signal and increasing the sound channel rejection. It should be remembered that most of the 42 Mc/s. interference from amateurs falls in the lower side-band. For areas of very low television field-strength

the reduced overall noise level should be advantageous, quite apart from the considerable reduction in sensitivity in the region of the 3rd harmonic from a 14 Mc/s. transmitter. In addition, there will be appreciable rejection of the 12th harmonic of a 3·5 Mc/s. transmitter and the 6th harmonic of all 7 Mc/s. transmissions, all of which in low field-strength areas might have a very damaging effect upon the picture.

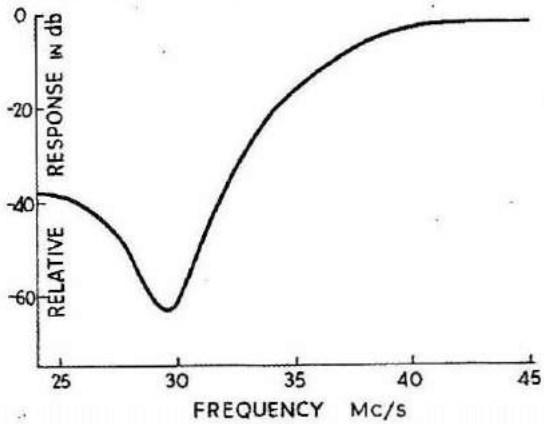


Fig. 28.
Response curve of 29 Mc/s. filter showing the points where maximum attenuation occurs.

The degree of rejection obtained by this means may be of the order of 25 db or more.

The conversion to single side-band reception should not be attempted by any other than an experienced television engineer, but the procedure is not difficult and good results can be obtained quite easily.

Obviously the owner must be willing to have the conversion made, and considerable tact should be used in suggesting any modifications to his apparatus. The general improvement in the signal-to-noise ratio, however, is an important point and should be explained carefully. Needless to say as much harmonic suppression as possible should already be in use in the transmitter.

Summary

From the foregoing it will be seen that the curing of Television interference from amateur radio transmitters, although at first sight apparently a difficult problem, is by no means insuperable. It is an aspect of Amateur Radio that is becoming rapidly more important with the increasing area of the Television service, coupled with longer programme hours. This, combined with the rapidly expanding number of viewers renders it an essential problem that must be solved by almost all amateurs sooner or later. Fortunately, in nearly every case, one of the remedies suggested, or a combination of two or more, will prove effective.

Once again it is urged that immediate attention be paid to any complaints received, and the matter investigated with as much tact, patience, and forebearance as the individual case requires.

Band. Mc/s.	Harmonic.	Range. Mc/s.	Chance of Interference.
1·715– 2·0	30th, 38th,	51·5–76	Negligible
3·5 – 3·8	16th, 17th, 18th	56 –68·4	Moderate
7 – 7·3	9th	63 –65·7	Slight
14·0 –14·4	4th	56 –57·6	Slight
21 –21·4	3rd	63 –64·2	Moderate
28 –30	2nd	56 –60	Serious
58·5 –60	Fundamental	58·5–60	Serious

TABLE III.

Shows the position for the frequencies to be used by the Birmingham Television Station.

Car Ignition

Although not strictly applicable to this booklet, a few points regarding the suppression of car ignition interference to television are given here so that amateurs may lead the way by suppressing their own vehicles, and be in a position to answer questions on the subject.

In general the greatest source of trouble is the ignition system, and the simplest cure in most cases is to insert a resistor having a value between 5,000 and 15,000 ohms in the lead from the distributor to the coil, at the distributor end. A suitable resistor is made by *Belling & Lee*, and is specially constructed so that it may easily be connected to the distributor and lead. The type No. is L1274, and the price is 1/6. If interference still persists then a resistor of any value between 5,000 and 25,000 ohms should be inserted at the plug end of each of the leads from the distributor to the sparking plugs.

If it is desired to suppress still further, another series of resistors may be inserted at the distributor end of these leads, provided the total resistance in each lead does not exceed 25,000 ohms.

Windscreen wipers are another source of trouble and may be suppressed by fixing a condenser of ·5 or 1 μF from each terminal to chassis. Electric petrol pumps may be suppressed in the same way.

In the case of the dynamo, if it is of the third brush type, which is more usual, condensers of ·5 or 1 μF should be connected between the field terminal and frame, and between the insulated brush terminal, or terminals, and the frame.

In every case connecting leads should be kept as short as possible and should not exceed 3" in length at any point.

In reply to any argument that suppression affects performance, it should be pointed out that all Service vehicles are suppressed to a very high degree, and after exhaustive bench and road tests no falling-off of performance is apparent. Furthermore, the Automobile Research Association has investigated the matter and concludes that no effect due to the use of correctly designed suppressors can be detected at various speeds and under load.

APPENDIX

This appendix gives a list of the various types of Television receivers in order of makers names and shows the type of circuit employed in each case. Where a superheterodyne circuit is used details of the intermediate frequency, oscillator and image frequency are given.

Except where otherwise stated the receivers utilise both sidebands. This implies, in the case of the vision portion of the circuit, that the effective intermediate and image frequency bandwiths extend about 2 to 2·5 megacycles either side of the figures quoted.

Name	Model	Circuit		I.F. in Mc/s.		Oscillator Frequency in Mc/s.	Image Frequency in Mc/s.	
		Vision	Sound	Vision	Sound		Vision	Sound
Alba ..	T411	T.R.F.	T.R.F.	—	—	—	—	—
	T421	T.R.F.	T.R.F.	—	—	—	—	—
Beethoven ..		S.H.	S.H.	13·0	16·5			
Bush ..	T91	T.R.F.	S.H.	—	·725	40·725	—	40·0
	TV1	T.R.F.	S.H.	—	·725	40·725	—	40·0
	TV2	T.R.F.	S.H.	—	·725	40·725	—	40·0
Ecko ..	All	T.R.F.	T.R.F.	—	—	—	—	—
Cossor ..	54	S.H.	S.H.	6·0	2·5	39·0	33·0	36·5
	65	S.H.	S.H.	6·0	2·5	39·0	33·0	36·5
	137 237	S.H.	S.H.	5·3	1·8	39·7	34·4	37·9
	437	S.H.	S.H.	5·3	1·8	39·7	34·4	37·9
	900 1200	S.H.	S.H.	6·0	2·5	39·0	33·0	36·5
	901, 902, 912	T.R.F.	S.H.	—	2·2	39·3	—	37·1
Dynatron ..	TV21	T.R.F.	T.R.F.	—	—	—	—	—
Etronic ..	T12	T.R.F.	T.R.F.	—	—	—	—	—
Ferguson ..	841T	T.R.F.	T.R.F.	—	—	—	—	—
	842T	T.R.F.	T.R.F.	—	—	—	—	—
Ferranti ..	T136	T.R.F.	S.H.	—	10·0	31·5	—	21·5
	T138	T.R.F.	T.R.F.	—	—	—	—	—
	T1146	T.R.F.	S.H.	—	10·0	31·5	—	21·5
	T1246	T.R.F.	S.H.	—	10·0	31·5	—	21·5
G.E.C. ..	BT0124	S.H.	S.H.	6	2·5	39·0	33·0	36·5
	BT3701	S.H.	S.H.	3	·45	41·95	38·95	42·4
	BT3702	S.H.	S.H.	3	·45	41·95	38·95	42·4
	BT8090	S.H.	S.H.	3	·6	42·1	39·1	42·7
	BT8121	S.H.	S.H.	3	·45	41·95	38·95	42·4
	BT8161	S.H.	S.H.	3	·45	41·95	38·95	42·4
	BT9121	S.H.	S.H.	6	2·5	39·0	33·0	36·5

Name	Model	Circuit		I.F. in Mc/s.		Oscillator Frequency in Mc/s.	Image Frequency in Mc/s.	
		Vision	Sound	Vision	Sound		Vision	Sound
G.E.C. ..	BT9122	S.H.	S.H.	3	·45	41·95	38·95	42·4
	BT7092	S.H.	S.H.	13·5	10·0	31·5	18·0	21·5
	BT7094	S.H.	S.H.	13·5	10·0	31·5	18·0	21·5
H.M.V. ..	900	T.R.F.	S.H.	—	·46	41·04	—	40·58
	901	T.R.F.	S.H.	—	1·5	40·0	—	38·5
	902	T.R.F.	S.H.	—	·46	41·04	—	40·58
	902A	T.R.F.	S.H.	—	·46	41·04	—	40·58
	903	S.H.	S.H.	9·0	5·5	36·0	27·0	30·5
	904	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	905	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	907	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	1800	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	1801	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	1802	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	1803	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	1804	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	1850	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	1901	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
Haynes ..	HR77	T.R.F.	S.H.	—	5·0	36·5	—	31·5
	HR88	T.R.F.	S.H.	—	3·0	38·5	—	35·5
Invicta ..	All	T.R.F.	T.R.F.	—	—	—	—	—
K.B. ..		S.H.	S.H.	12·5†	9·0	32·5	20·0	23·5
McMichael	De Luxe	S.H.	S.H.	13·0	9·5	32·0	19·0	22·5
	Standard	T.R.F.	T.R.F.	—	—	—	—	—
Marconiphone ..	701	T.R.F.	S.H.	—	·46	41·04	—	40·58
	702	T.R.F.	S.H.	—	1·5	40·0	—	38·5
	703	T.R.F.	S.H.	—	·46	41·04	—	40·58
	704	S.H.	S.H.	9	5·5	36·0	27·0	30·5
	705	T.R.F.	S.H.	—	·46	41·04	—	40·58
	706	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	707	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	709	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	710	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	711	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	712	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	713	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
	VT50A	S.H.	S.H.	8·0	4·5	37·0	29·0	32·5
Murphy ..	A42V	S.H.	S.H.	4·25	·75	40·75	36·5	40·0
	A56V	S.H.	S.H.	4·25	·75	40·75	36·5	40·0
	A58V	S.H.	S.H.	4·25	·75	40·75	36·5	40·0
	V86CA	S.H.	S.H.	13·5	10·0	31·5	18·0	21·5
	V114	S.H.	S.H.	13·5	10·0	31·5	18·0	21·5
	V116	S.H.	S.H.	13·5	10·0	31·5	18·0	21·5
	V134	T.R.F†	T.R.F.	—	—	—	—	—
	V136	T.R.F†	T.R.F.	—	—	—	—	—

Name	Model	Circuit		I.F. in Mc/s.		Oscillator Frequency in Mc/s.	Image Frequency in Mc/s.	
		Vision	Sound	Vision	Sound		Vision	Sound
Philco ..	A1707	T.R.F.	T.R.F.	—	—	—	—	—
	A1708	T.R.F.	T.R.F.	—	—	—	—	—
Philips ..	All	S.H.	S.H.	13·2*	9·7	31·8	18·6	22·1
Pilot ..	VS9	T.R.F.	T.R.F.	—	—	—	—	—
Pye ..	B16T	T.R.F.	T.R.F.	—	—	—	—	—
	D16T	T.R.F.	T.R.F.	—	—	—	—	—
	B18T	T.R.F.	T.R.F.	—	—	—	—	—
	D18T	T.R.F.	T.R.F.	—	—	—	—	—
R.G.D. ..	All	S.H.	S.H.	13·0	9·5	32·0	19·0	22·5
Ultra ..	T22	S.H.	S.H.	5·8 *	2·3	39·2	33·4	36·9
	V470	S.H.	S.H.	10·7 †	7·2	34·3	23·6	27·1

* Single Side Band (Lower)
† Single Side Band (Upper)

Acknowledgements

The co-authors acknowledge their indebtedness to the *British Radio Equipment Manufacturers' Association* and members of that body for the information contained in the appendix; to the members of the R.S.G.B. Television Sub-Committee for general assistance; and to Messrs. P. F. Cundy, A.M.I.E.E., G2MQ, and R. L. Varney, A.M.I.E.E., G5RV, for providing details of television suppression devices.

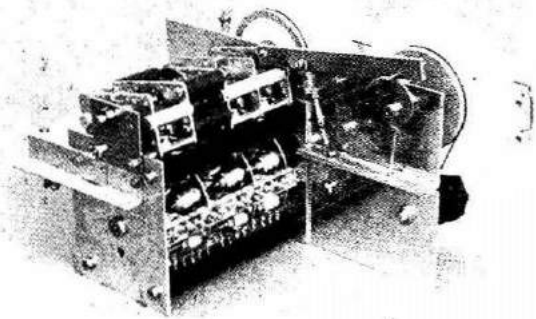
Acknowledgements are also due to *Messrs. Kolster Brandes, Ltd.*, for granting permission to reproduce Figs. 10 and 11. The original photographs appeared in an article by C. L. Smyth, published in "COMMUNICATIONS."

PARK RADIO

212 High Street North, East Ham, E.6

EAST LONDON'S **"DENCO"** STOCKISTS

The CT4 Coil Turret described below is only one of the many DENCO turrets available. Its important features are the constant gain characteristics from 1·65 to 36 Mc/s.; special differential input circuit permitting matching or coupling of a wide range of aerial impedances at all frequencies from 4.8 to 36 Mc/s.; concentric, air spaced trimmers for each coil in the unit; coils wound on low loss polystyrene, with adjustable iron dust cores; calibrated band spread of five amateur bands including 21 Mc/s.



The CT4 is a complete all wave tuning unit, mainly for use in communication receivers, having one high gain RF stage, mixer and separate oscillator and covering, in six ranges, 175 kc/s, to 36 Mc/s with an I.F. of 1.6 Mc/s. The well-known Denco turret assembly arrangement is used, this turret superseding the CT3 which is now out of Production.

Also available are coils, I.F.'s, chassis, chassis kits, etc., and we can claim to be the cheapest in London for resistors, condensers, electrolytics, and most radio components.

PARK RADIO, 212 High St. North, East Ham, London, E.6

Radio Society of Great Britain